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# OUTLOOK FOR THE MACKEREL FISHERY IN 1932 [1]

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## INTRODUCTION [2]

### PURPOSE

In a fishery the yield of which fluctuates as widely as does that the mackerel, the economic losses due to alternating periods of arcity and plenty may attain great magnitude. In years of arcity the combined effect of high prices and of unavailability of ackerel reduces the number of consumers so that an unexpected crease in yield finds a distinctly limited market and prices sink to w levels spelling disaster to the fishermen and sometimes causing tual wastage of this peculiarly perishable product. If these changes production could be foreseen, such events would be anticipated d an adjustment of distributing facilities might prevent the deoralizing effects of glutted markets.

Still another danger menacing a fluctuating fishery is man's own terpretation of conditions of the resource. A decline in productivity, especially if extending through several years, is readily misken for depletion due to overfishing, and unwise, unnecessary strictions may be imposed through the activity of overzealous conrvationists. This very thing happened in the 1880's when a sharp ecline in the yield of mackerel was followed by congressional action ohibiting mackerel seining prior to June 1, for five years. Those

[1] Approved for publication, Apr. 26, 1932.
[2] This is the second of a series of reports giving forecasts of future abundance of ckerel. The first appeared as Fishery Circular No. 4, August, 1931. In order to render details of this report intelligible to those who do not have access to the previous ort, some parts of the explanatory and descriptive sections have been repeated herein.

familiar with the history of the mackerel fishery will recall th this closure was without beneficial effects and was abandoned the end of the 5-year period. Even in present times the Bureau Fisheries receives sufficient suggestions for restrictions of one so or another to indicate that there is pressure in favor of regulatio on the part of many who are unfamiliar with the merits of the ca they advance. The very existence of predictions on changes i abundance constitutes insurance against restrictive measures whe the nature of the anticipated changes proves that fears of overfishin are baseless.

While the investigation upon which predictions may be based ha been in progress too short a time to provide the finality that goes wit age and experience, it has provided an understanding of fluctuation that considerably narrows our idea of the possibilities in store fo the fishery during the coming season. Without the studies upo which this report is based, it could not be foreseen whether the 193 yield might be larger or smaller than last year's, whether it migh decrease to a level as low as 1910 when the vessel fishery took onl 4,000,000 pounds, or increase to the high levels of the early 1880 when 100,000,000 yields were harvested. However, with the fact now available, we know that no such extremes are likely to b experienced.

At the same time it should be emphasized that there are man uncertainties involved in compiling the estimates of yields to b anticipated for 1932. The forecast is based on changes that hav occurred during the last five years with a regularity indicating th existence of controlling principles, which may be expected to operat in the future as they have in the past. But nature rarely repeat herself exactly. Variations have been noted during the past fiv years and may be expected to occur in the future. During the shor term of these studies it has been possible only to gage variability b the comparison of a few repetitions of similar events.

Although certain events have recurred regularly enough to for a basis for looking forward toward their repetition in the future one important feature has so far defied our efforts to connect caus and effect closely enough to serve prediction purposes; that is, th abundance of yearling mackerel known to the trade as "blinks" and "tinkers." In some years there is practically none of these; i other years they afford large catches. So far we have been unabl to find evidence in one year that would indicate the abundance o yearlings to be expected the following year. Therefore, our pre dictions must be limited to the larger mackerel weighing 1 pound o more.

Though the forecast lacks definiteness, the fluctuations in th mackerel fishery have been so extreme that even this narrowing dow of possibilities appears to have practical value warranting the pub lication of certain results in advance of an exhaustive technical re port on the mackerel studies. Its purpose is to make available t the fishermen the existing facts bearing on the coming season's pros pects and to place our estimates on record so that future event may be compared with the prediction and so build up experienc that may be used to rectify errors in method, and to appraise th value to the fishery of this series of forecasts.

## THE MACKEREL FISHERY

*Distribution.*—The mackerel, *Scomber scombrus*, ranges along the merican coast from North Carolina to Newfoundland. United tates fishermen make most of their catches between Virginia and aine with a number of vessels making one or two trips to the offing Nova Scotia. The latter fishery is locally termed "Cape Shore" the fishermen and is so designated in this report. The only region aving mackerel in abundance and not visited by the United States shermen in recent years is the Gulf of St. Lawrence. Hence the nited States fishery may be assumed to cover nearly the entire ormal range of the mackerel (on this side of the Atlantic).

There is a decided seasonality in the runs of mackerel. The fishing ways begins in April when the mackerel are found off the Virginia ast. A month later they are off the New Jersey and Long Island ores, and by the first of June the fishing is concentrated off south- n New England. At that time mackerel also appear off the coast Nova Scotia and some of the seiners make trips to the Cape Shore hile the remainder continue to fish off southern New England. By e end of June the mackerel disappear from south of Cape Cod and rtually all fishing is done in the Gulf of Maine. During the month July most of the fishing takes place in the offing of Cape Cod but on thereafter spreads northward often to Monhegan, Me.

*Methods of fishing.*—Mackerel are caught by a number of forms of ear. Chief among these is the purse seine, next the gill net, and stly, several forms of shore gear such as pound nets and floating aps. The offshore fishery, prosecuted mostly by vessels of 5 net tons id over (as measured by the United States Customs Service), em- oys only purse seines and gill nets. This branch of the fishery is e mainstay of the American market. Landings are made at rela- vely few ports, and it is possible to secure statistics and samples of e catch through the efforts of a few field observers. Therefore, our ata relate mainly to the vessel fishery. The pound nets and traps e operated at widely scattered places; their catch is sold locally, id therefore is not accessible to thorough observation by a small aff. Since it accounts for a relatively small catch, the omission of e shore fishery is not serious.

*Seining.*—The purse seine is an ingenious contrivance by means which a school of fish is completely surrounded by netting. In e mackerel fishery the adjective is dropped and the gear is called seine; the method of fishing is called seining; and the vessel using is method is called a seiner. For the sake of brevity these terms e adopted in this report. The vessel using a seine cruises over the shing grounds with a member of the crew posted at the masthead oking for schools of mackerel. When one is sighted the crew mans seine boat and a skiff or dory. One end of the seine is buoyed by e skiff while the remainder of the seine is paid out over the stern the seine boat while the latter is towed around the school by the ssel. When the two ends of the seine are brought together the wline is cast off and the vessel stands by while the seine is "pursed" means of a line running through rings at the lower border of the ine. A weight or tom is run down the purse line to facilitate arsing and to hold the lower border of the seine in the proper depth.

After pursing, enough of the netting is hauled in to concentrate th mackerel in one portion of the seine, the vessel comes alongside, an the fish are brailed to the deck of the vessel.

Mackerel seining has a number of peculiarities that must be recog nized when gaging abundance by means of the seine catch. The revolve about the essential fact that the fish must be sighted befor they are caught. In the first place this means that good fishin depends on the presence of schools at the very surface of the sea The mackerel need only descend to deeper levels to escape the fishery This undoubtedly happens at times when the sea seems devoid o mackerel. Then too, the fishery is very sensitive to weather condi tions, for the visibility of schools is affected by the roughness of th sea and the quality of the light. In the spring and fall fishing i done only on dark nights when the mackerel schools cause a glow which is generated by the myriads of luminescent organisms a they are disturbed by the movement of the mackerel. On moonligh nights, the luminescence is so much less conspicuous that practicall no seining is done. During the summer months seining is done i the daytime when the mackerel schools show as dark patches belo the surface or by the rippling of the water as they break the surface

Practically all sizes of mackerel may be caught by seiners, but i is possible to distinguish the size of fish before setting the seine an consequently, the small ones (blinks and tinkers) are avoided whe prices are low. There appears to be a tendency for underrepresenta tion of the largest sizes, perhaps, because at times they may be mor scattered and swimming at deeper levels than the medium and smal sizes.

*Netting.*—Second in importance is the method of fishing terme "netting." A completely descriptive name would be "drift gil netting" for the nets consist of vertical walls of webbing with upp borders held at the surface by cork buoys and lower borders hel down by leads along the foot line. They are set out end to end i long strings. The mackerel are caught when their heads enter th meshes, where they are gilled. The nets are usually set in th evening and hauled in the morning.

Netting takes place in two distinct seasons. The principal catc is made south of Cape Cod in April and May where the netters fis largely on the moonlight nights. They report that the luminescenc on dark nights renders the nets too conspicuous for effective fishing The spring season extends into June in Massachusetts Bay. It the terminates to be resumed again in October, November, and Decem ber, when most of the fishing is done in the offing of Cape Ann.

## HISTORY OF PRODUCTION

Perhaps no fishery of equal commercial importance has been sub ject to more extreme variation in productivity than has the mackere fishery off the coast of North America. It has yielded as high a 120,000,000 pounds in 1884 and within two years declined to a mer 20,000,000-pound catch. In 1910 the vessel catch was only 4,000,00 pounds, but again in 1926, 46,000,000 pounds were caught. The pro duction curve given in Figure 1 illustrates this variability.

A conspicuous feature of the curve is the well-sustained increase since 1921. The yields of recent years, although high compared with those of the years between 1885 and 1921, are none the less considerably below the best yields of the period ending in 1884. It is pertinent to inquire whether these yields represent a complete or only a partial restoration of the abundance of mackerel which characterized the early years of the fishery. Methods of fishing and distribution have changed so greatly that exact comparison is difficult. The modern fleet, although consisting of fewer vessels, has the advantage of auxiliary power. Perhaps the greatest difference is in marketing methods. Formerly, virtually the whole catch was salted; recently nearly the whole catch has been landed fresh. The effect of the change has been threefold. The wider markets reached by the salted product were probably capable of absorbing greater quantities of mackerel than can be marketed profitably at present, thus causing a

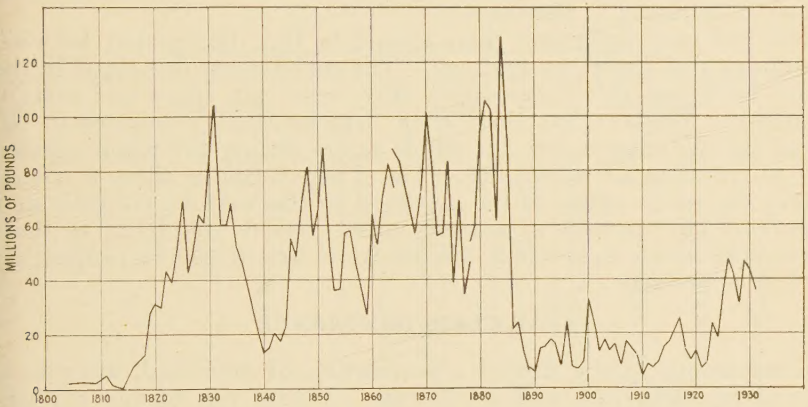


FIGURE 1.—Annual catch of mackerel by American vessels, 1804–1931. Data for 1804 to 1864 consist of total quantity of salt mackerel inspected in Massachusetts; data for 1864 to 1878 consist of the salt mackerel inspected in New England; data for 1878 to 1889 consist of the catch of the salt mackerel fleet of New England; data for 1889 to 1905 consist of the catch of the salt mackerel fleet of New England plus fresh mackerel receipts in Boston; data for 1905 to date consist of the total landings of the American mackerel fleet. All quantities were converted to the basis of fresh round mackerel

greater incentive to intensive fishing. Fishing could be carried on with unabated vigor during the parts of the season when mackerel were most easily caught. During recent years, however, the fleet occasionally has been forced to curtail production at the very times when fishing is best, for fresh fish markets are readily glutted. Finally, although at first thought it would appear that modern vessels equipped with auxiliary power would waste less time in running between the fishing grounds and port, it is probable that the reverse is the case, for the demand for fresh fish requires that each catch, though it fall far short of the capacity of the vessel, be landed promptly.

In any case, whether recent yields represent a complete or only a partial restoration of abundance, there can be no doubt that a considerable increase in abundance has occurred; and since no protection has been afforded the mackerel for many years, it is apparent that the increase has been due to natural causes.

## FLUCTUATIONS AND THEIR CAUSES

Studies on the European mackerel have established in certain instances the dependence of the catch on hydrographical and meteorological conditions. For instance, Allen [3] and Russell [4] have shown the connection between February and March sunshine and May catches in the mackerel fishery off the south and west coast of England; and Jensen [5] has shown a close correlation between September water temperature and mackerel landed at Copenhagen from the sound and eastern Baltic during September.

We have not yet found any unmistakable connection between the success of the American fishery and environmental conditions. Although the weather and the hydrographic conditions undoubtedly affect the availability of mackerel and cause local and temporary changes in the catch, our data indicate that there is a more profound influence controlling the annual catch; that is, the fluctuating abundance of mackerel in the sea.

It is not surprising that there should be this discrepancy between European and American findings. The correlations described in the above European references apply only to certain times and certain localities. Nowhere has there been demonstrated a connection between the abundance over the whole range during the whole season and environmental conditions. The United States fishery covers nearly the whole range of the mackerel in the western Atlantic and apparently the periods of scarcity offset periods of plenty so that, during the season as a whole, the mackerel are caught in proportion to their abundance.

## YEAR-CLASS DOMINANCE

Fluctuations in the size of a population of any kind, anywhere, depend on birth rate and death rate. Where the former exceeds the latter the population will increase, and, conversely, where the latter exceeds the former the population will decline. Where consideration is limited to a certain area, migrations into or from the area must also enter into the net result. The mackerel investigations have been essentially a study of the first two points: Birth rate and death rate. Migrations have been ignored for the time being because our field of observation includes almost the entire range of the western Atlantic race of the species, and because it has not been necessary to resort to any extensive migration theories to account for the major phenomena observed.

Since the nature of the population precludes any direct count of births or deaths, various indirect means have been employed to estimate these equivalents. Practically the only means of studying the mackerel population is through the data made available by the

[3] Allen, E. J. Mackerel and Sunshine. Journal, Marine Biological Association, N. S., vol. 8, 1907–1910, pp. 394–406.

[4] Russell, E. S. Report on log-book records relating to mackerel, pilchards, and herring, kept by fishermen during the years 1895–1911. Board of Agriculture and Fisheries, Fishery Investigations, Series II, Vol. III, No. 1, 1915.

[5] Jensen, A. J. C. On the influence of hydrographical factors upon the yield of the mackerel fishery in the sound. Report of the Danish Biological Station. Copenhagen, 1930.

ctivities of the commercial fishing fleet. This forms our instrument of observation, through which a number of pertinent facts may e determined. The principal ones used in this report are the quanities of mackerel caught and the sizes or ages of the fish making up ne catch. In other words, the fishing fleet provides a quantitative nd qualitative sampling of the population. Thanks are due the shermen who have secured for us many items of information, often t considerable expenditure of time and trouble.

From the reports of quantities of mackerel landed and from measurements of thousands of mackerel taken at random from the atch, there has been determined by suitable compilations the number of mackerel of each size (in half-centimeter groupings) landed uring the past six years. These data are given in Tables 1 and 2 nd are shown graphically in Figures 2 and 3.

TABLE 1.—*Sizes of mackerel in the seine catch annually, 1926–1931, weighted according to the quantities caught*

[Numbers represent thousands of fish; that is, 000 omitted]

| Length in centimeters | Frequencies | | | | | | Length in centimeters | Frequencies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1926 [1] | 1927 | 1928 | 1929 | 1930 [1] | 1931 | | 1926 [1] | 1927 | 1928 | 1929 | 1930 [1] | 1931 |
| .5 | | | | 6 | | | 35.5 | 384 | 14 | 2 | 137 | 1,145 | 67 |
| .0 | | | | 6 | | | 36.0 | 747 | 55 | 3 | 112 | 1,135 | 105 |
| .5 | | | | 6 | | 2 | 36.5 | 1,618 | 168 | 7 | 100 | 1,186 | 169 |
| .0 | | | | 46 | | 8 | 37.0 | 2,889 | 570 | 18 | 106 | 1,043 | 306 |
| .5 | | | | 52 | | 22 | 37.5 | 4,627 | 1,357 | 45 | 81 | 715 | 367 |
| .0 | | | | 58 | | 38 | 38.0 | 5,386 | 2,796 | 189 | 83 | 488 | 458 |
| .5 | | | | 40 | | 36 | 38.5 | 4,700 | 4,005 | 520 | 43 | 289 | 668 |
| .0 | | | | 11 | | 28 | 39.0 | 2,972 | 4,519 | 1,270 | 53 | 186 | 1,157 |
| .5 | | | | | | 33 | 39.5 | 1,546 | 3,657 | 2,223 | 158 | 97 | 1,328 |
| .0 | | | | 1 | | 45 | 40.0 | 1,013 | 2,562 | 2,737 | 447 | 139 | 1,252 |
| .5 | | | | 1 | | 34 | 40.5 | 706 | 1,522 | 2,624 | 975 | 212 | 967 |
| .0 | | | | | | 39 | 41.0 | 545 | 969 | 1,814 | 1,664 | 447 | 606 |
| .5 | | | | 3 | | 32 | 41.5 | 354 | 619 | 1,174 | 1,919 | 798 | 603 |
| .0 | | | 7 | 8 | 2 | 17 | 42.0 | 232 | 355 | 611 | 2,003 | 1,432 | 875 |
| .5 | | | 31 | 12 | 3 | 12 | 42.5 | 120 | 183 | 314 | 1,364 | 1,470 | 1,176 |
| .0 | | | 48 | 29 | 2 | 19 | 43.0 | 77 | 114 | 162 | 836 | 1,400 | 1,234 |
| .5 | | | 32 | 38 | 3 | 79 | 43.5 | 50 | 68 | 105 | 423 | 1,208 | 1,204 |
| .0 | | | 8 | 69 | 10 | 51 | 44.0 | 52 | 65 | 52 | 243 | 842 | 1,019 |
| .5 | | | 1 | 81 | 12 | 147 | 44.5 | 76 | 67 | 44 | 142 | 439 | 657 |
| .0 | | | | 132 | 21 | 210 | 45.0 | 97 | 88 | 37 | 93 | 365 | 451 |
| .5 | | | | 159 | 32 | 328 | 45.5 | 93 | 115 | 35 | 62 | 246 | 255 |
| .0 | | | 1 | 318 | 30 | 490 | 46.0 | 110 | 74 | 36 | 60 | 110 | 210 |
| .5 | | | 6 | 419 | 49 | 596 | 46.5 | 77 | 96 | 40 | 42 | 63 | 109 |
| .0 | | | 10 | 519 | 34 | 642 | 47.0 | 88 | 81 | 46 | 56 | 75 | 81 |
| .5 | | 1 | 32 | 536 | 60 | 680 | 47.5 | 59 | 57 | 39 | 42 | 57 | 48 |
| .0 | | | 55 | 750 | 75 | 800 | 48.0 | 38 | 49 | 25 | 29 | 52 | 39 |
| .5 | | 1 | 100 | 1,071 | 70 | 833 | 48.5 | 29 | 39 | 21 | 21 | 35 | 26 |
| .0 | | 1 | 145 | 1,529 | 93 | 807 | 49.0 | 19 | 16 | 16 | 24 | 31 | 28 |
| .5 | 6 | 1 | 176 | 2,118 | 213 | 723 | 49.5 | 26 | 13 | 9 | 12 | 13 | 9 |
| .0 | 16 | 1 | 257 | 2,769 | 344 | 552 | 50.0 | 10 | 5 | 4 | 10 | 17 | 9 |
| .5 | 9 | 1 | 253 | 3,856 | 769 | 359 | 50.5 | 4 | 6 | 3 | 3 | 3 | 2 |
| .0 | 10 | 1 | 317 | 4,206 | 1,170 | 215 | 51.0 | 3 | 1 | 1 | 4 | 4 | 2 |
| .5 | 7 | 2 | 263 | 3,585 | 1,303 | 151 | 51.5 | 2 | 3 | 1 | 1 | 1 | 2 |
| .0 | 12 | 2 | 238 | 2,892 | 1,512 | 51 | 52.0 | 3 | | 2 | | 1 | 5 |
| .5 | 17 | 2 | 138 | 1,549 | 1,194 | 64 | 52.5 | 1 | | | | | |
| .0 | 26 | 10 | 83 | 867 | 928 | 42 | 53.0 | | | | 3 | | |
| .5 | 57 | 6 | 52 | 434 | 852 | 16 | 53.5 | | | 1 | | | |
| .0 | 85 | 4 | 23 | 370 | 954 | 33 | | | | | | | |
| .5 | 116 | 6 | 10 | 221 | 974 | 43 | | 29,327 | 24,360 | 16,520 | 40,299 | 27,527 | 23,836 |
| .0 | 213 | 13 | 4 | 181 | 1,074 | 65 | | | | | | | |

[1] Revised since the last report.

TABLE 2.—*Sizes of mackerel in the net catch annually, 1926–1931, weighted according to the quantities caught*

[Numbers represent thousands of fish—that is, 000 omitted]

| Length in centimeters | Frequencies | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spring | | | | | | Fall | | | | | |
| | 1926 [1] | 1927 | 1928 | 1929 | 1930 | 1931 | 1926 | 1927 | 1928 | 1929 | 1930 | 193 |
| 33.5 | | | | | 2 | | | | | | | |
| 34.0 | | | | | 3 | | | | | | | |
| 34.5 | | | | | 2 | | | | | | | |
| 35.0 | | | | | 2 | 1 | | | | | 1 | |
| 35.5 | 3 | | | | 5 | | | | | | | |
| 36.0 | 9 | 1 | | | 4 | 1 | | | | | 1 | |
| 36.5 | 30 | 2 | | 1 | 7 | | | | | | 2 | |
| 37.0 | 51 | 4 | | 1 | 8 | 2 | | | | | 13 | |
| 37.5 | 85 | 19 | 1 | 3 | 6 | 2 | | | | | 21 | |
| 38.0 | 131 | 43 | 3 | | 7 | 6 | | | | 1 | 32 | |
| 38.5 | 121 | 75 | 20 | 1 | 6 | 4 | | 2 | | 1 | 39 | |
| 39.0 | 99 | 97 | 56 | 3 | 3 | 13 | 1 | 3 | | 2 | 32 | |
| 39.5 | 70 | 93 | 100 | 23 | 5 | 15 | 5 | 4 | 1 | 4 | 14 | |
| 40.0 | 56 | 84 | 169 | 63 | 12 | 17 | 7 | 9 | 4 | 3 | 6 | |
| 40.5 | 53 | 62 | 192 | 160 | 41 | 29 | 14 | 21 | 11 | 1 | 5 | |
| 41.0 | 45 | 36 | 166 | 252 | 106 | 25 | 16 | 33 | 26 | 2 | 5 | |
| 41.5 | 38 | 30 | 152 | 298 | 190 | 40 | 22 | 45 | 44 | 6 | 5 | |
| 42.0 | 28 | 21 | 95 | 339 | 331 | 86 | 13 | 45 | 75 | 13 | 15 | |
| 42.5 | 17 | 13 | 67 | 236 | 372 | 116 | 6 | 32 | 120 | 22 | 16 | |
| 43.0 | 12 | 8 | 47 | 168 | 351 | 130 | 4 | 21 | 141 | 35 | 18 | |
| 43.5 | 11 | 7 | 36 | 79 | 239 | 114 | 4 | 13 | 122 | 40 | 34 | |
| 44.0 | 18 | 8 | 18 | 42 | 176 | 100 | 2 | 9 | 114 | 43 | 52 | |
| 44.5 | 15 | 8 | 13 | 26 | 103 | 68 | 4 | 7 | 72 | 35 | 50 | |
| 45.0 | 24 | 10 | 10 | 13 | 51 | 43 | 5 | 4 | 47 | 29 | 52 | |
| 45.5 | 30 | 11 | 8 | 10 | 26 | 24 | 7 | 6 | 23 | 17 | 31 | |
| 46.0 | 29 | 9 | 9 | 6 | 11 | 22 | 3 | 8 | 19 | 7 | 20 | |
| 46.5 | 29 | 13 | 10 | 5 | 14 | 7 | 7 | 9 | 14 | 5 | 14 | |
| 47.0 | 22 | 11 | 7 | 8 | 9 | 5 | 1 | 8 | 17 | 3 | 8 | |
| 47.5 | 14 | 7 | 6 | 8 | 6 | 4 | | 5 | 22 | 2 | 7 | |
| 48.0 | 13 | 5 | 5 | 3 | 8 | 4 | 1 | 2 | 13 | 1 | 4 | |
| 48.5 | 5 | 3 | 3 | 3 | 1 | 7 | | 2 | 10 | | 2 | |
| 49.0 | 3 | 1 | 2 | | 3 | 2 | | 1 | 5 | | 1 | |
| 49.5 | 1 | 2 | 2 | 1 | 2 | 1 | | 1 | 4 | | | |
| 50.0 | | 2 | | | | | | | | | | |
| 50.5 | | | | | | | | 1 | | | | |
| 51.0 | | | | 1 | | | | | 1 | | | |
| 51.5 | 1 | | | | | | | | 1 | | 1 | |
| Total | 1,063 | 685 | 1,197 | 1,753 | 2,112 | 888 | 122 | 291 | 906 | 272 | 501 | 64 |

[1] Data revised since 1931 report.

It is evident from these figures that the sizes fall into pronounced groupings. Through detailed study of such groupings as shown in Figure 2 and the examination of the scales from thousands of mackerel, it has been found that each mass group consists of fish mainly of one year class; that is, mainly fish of a single year's spawning. For convenience we shall designate the classes by giving the year in which they were spawned; for instance, 1923 class refers to the mackerel that resulted from the spawning of 1923. Where there are several year classes separated in age by only one or two years and one of them is much more numerous than the other, the lesser ones are submerged, so to speak, in the greater. Thus the 1921 class is merged into the group characterized by the more abundant 1923 class, and in 1930 the few 1927 class mackerel are lost in the grouping made up of the very much more abundant 1928 class.

Considering each year's frequency as shown by Figure 2 we see that in 1926 practically all the mackerel were between 35 and 42

ntimeters (14 and 16½ inches) long, with most of them 36 to 39 ntimeters (14¼ to 15½ inches) long. Fish of the 1923 class made this group. Those around 39 to 42 centimeters (15½ to 16½ ches) were of the 1921 class. Since the areas of the curves are oportional to the number of fish of each size taken in the catch,

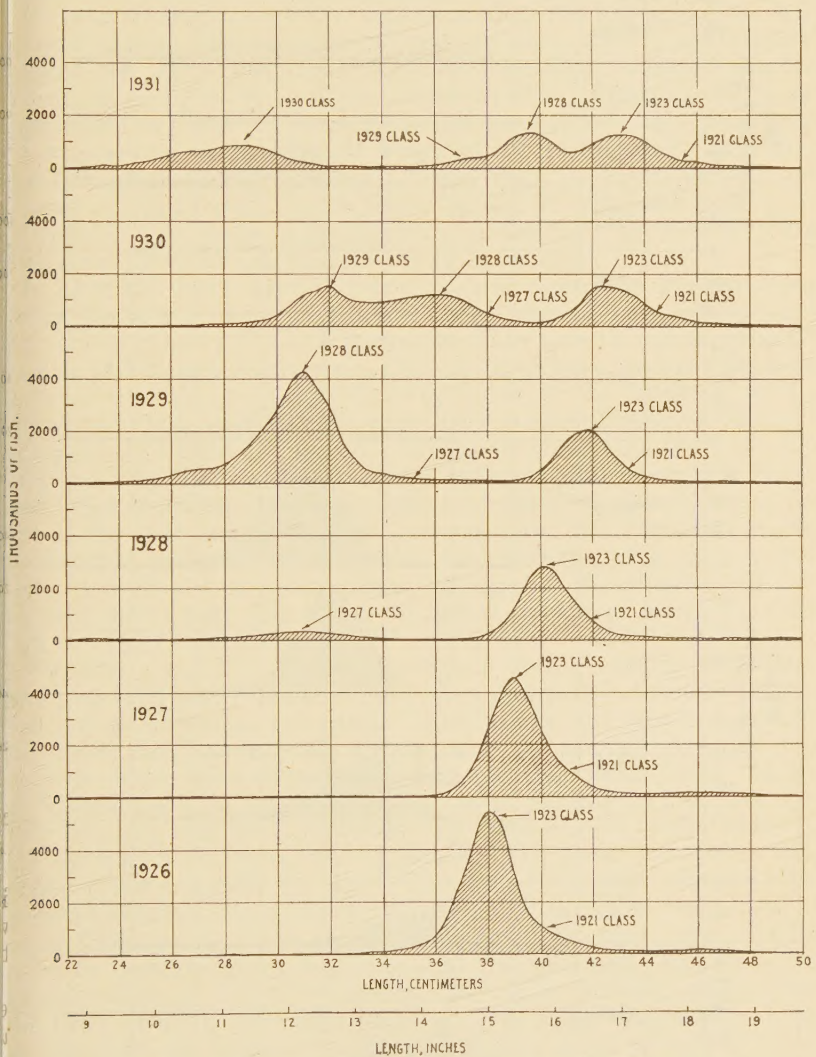


FIGURE 2.—Sizes of mackerel caught by seiners, 1926–1931. The areas under the curves are proportional to the numbers of mackerel landed

ıe dominance of the year's catch by the 1923 class is brought out in striking manner.

In 1927 we find the same group present, but somewhat larger due a year's growth.

They are again present in 1928, and here, too, they register some owth since the previous year. In addition, there is another group

28 to 33 centimeters (11 to 13 inches) long. These are mackerel o the 1927 class appearing in the seine catch in 1928 for the first tim as yearlings.

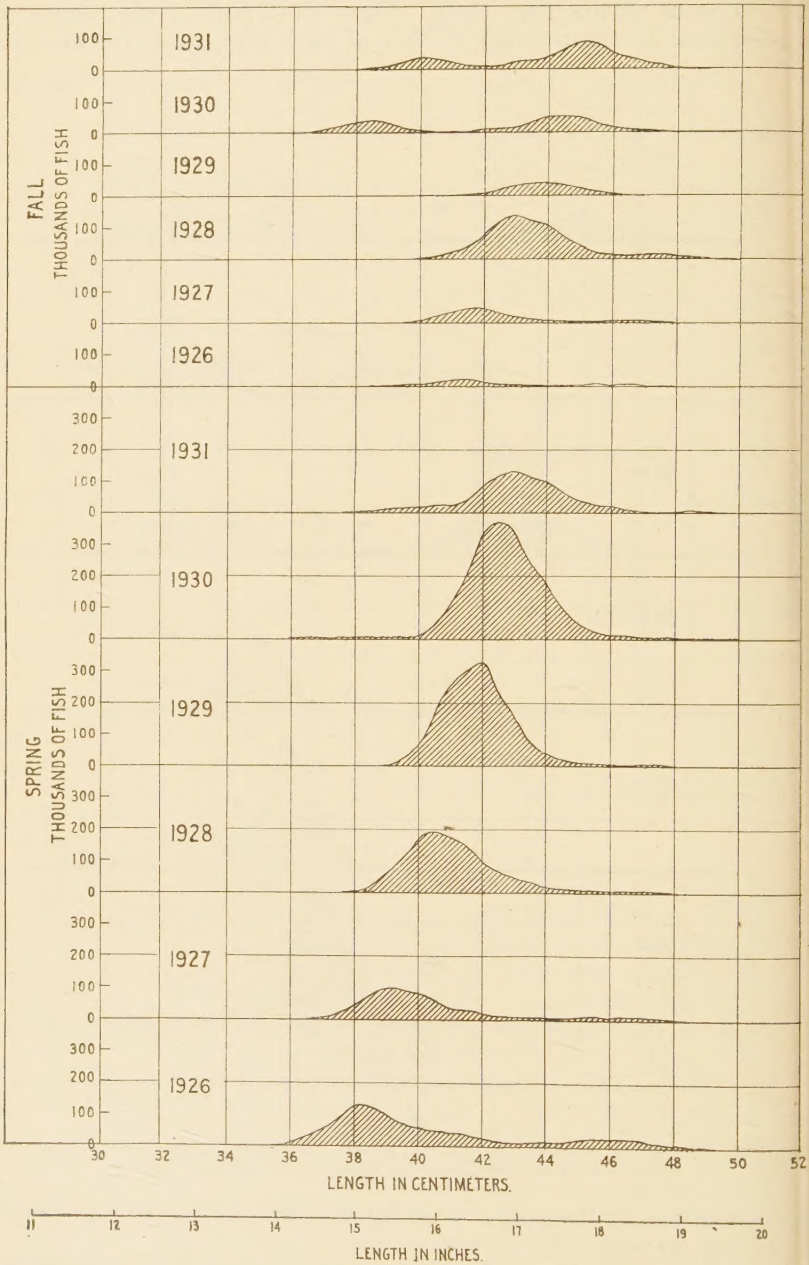


FIGURE 3.—Sizes of mackerel caught by netters, 1926–1931. The areas under the curves are proportional to the numbers of mackerel landed

In 1929 we again find the 1923 and 1921 classes forming distinct groups at lengths consistent with their growth since the previous

ear. A few mackerel of the 1927 class are present in the neighborood of 37 centimeters (14½ inches). But the outstanding feature f the 1929 frequency distribution is the tremendous group extending om 25 to 35 centimeters (10 to 13¾ inches). These were the yearng mackerel of the 1928 class and constituted the largest contingent enter the fishery since the appearance of the 1923 class.

In 1930 we find the groups represented in the previous year again resent, though the mackerel composing them are of appropriately rger sizes. The 1923 and 1921 classes are still strongly represented, rming a group at 40 to 46 centimeters (16 to 18 inches). The 1927 ass, small to begin with, has dwindled until it is hardly perceptible, it appears to cause a slight bulge at 38 centimeters (15 inches). he 1928 class, though notably reduced since the previous year, conitutes a distinct grouping between 34 and 38 centimeters (13½ and 5 inches). A noteworthy addition in the form of the 1929 class ppears at 30 to 33 centimeters (12 to 13 inches).

In 1931 the same groups reappear, and again the mackerel comosing them are of appropriately larger sizes. The 1929 class appears at lengths of 36 to 38 centimeters (14¼ to 15 inches), the 1928 ass at 38.5 to 40.5 centimeters (15¼ to 16 inches), and the 1923 class 2 to 45 centimeters (16¾ to 17¾ inches.) In addition we find new year class, that of 1930, providing mackerel between 25 and 31 ntimeters (10 and 12 inches). It may be noted that there are some ifferences in the sizes attained by different year classes at similar ges. For instance, the modal length of the 1930 class is lower than iat of the 1928 and 1929 at the same age, and the 1928 class reached somewhat greater length in 1931 than did the 1923 class in 1927, hen it was a full year older. A careful examination of scale mples shows that this is due to differences in growth rate rather an errors of interpretation.

We have seen that during the 6-year period certain year classes ave provided many mackerel and others have failed to make signifiint contributions to the catch. Turning to the production curve fig. 1) we shall see how the differences in the abundance of the varis year classes have caused the changes in the annual yield. In 1922 ie fishery was at a rather low ebb; but in passing to 1923 there is a oderate rise, doubtless occasioned by the entrance of the 1921 class ito the fishery as 2-year-old mackerel. The great increase in catch etween 1924 and 1926 was due to the entry of the 1923 class as shown y measurements made during a portion of the 1925 season and the ntire 1926 season. Since the spawnings of 1924, 1925, 1926, and 1927 iled to produce many mackerel and the 1921 and 1923 classes invitably declined due to mortality, the catch declined between 1926 nd 1928. But in 1928 another large year class was produced, and ie next year the mackerel of this class were large enough to handle ommercially; hence there was a sharp recovery in 1929. In 1930 the ecline in abundance of the 1921, 1923, and 1928 classes was almost ffset by the contribution of mackerel of the 1929 class appearing in ie fishery for the first time. In 1931 a further decline took place ue to the fact that the inevitable mortality of the 1921, 1923, 1928, nd 1929 classes was greater than the contribution made by the 1930 ass which appeared in the catch for the first time in 1931.

These facts justify the thesis that the fluctuations in the yield ar due mainly to changes in abundance of mackerel. The increase i 1926 may be safely attributed to the extraordinary numbers o mackerel added to the population. The moderate declines in 192 and 1928 are exactly what might be expected, since natural mortalit and the toll exacted by the fishery were not compensated for by an material additions. In 1929, 1930, and 1931 the natural course of th decline was offset partially by the addition of three new increments the 1928, 1929, and 1930 classes, but their numbers were not sufficien to halt the decline completely.

## PREVIOUS FORECASTS AND PRESENT DIFFICULTIES

In tracing the effects of year-class dominance on the annual catch the reader will have noted variations in the response of the fishery t the advent of new year classes. For instance, the 1923 class did no materially increase the catch until 1925, when it was 2 years old, an it produced a still larger catch in 1926. On the other hand, the 192 class increased the catch in the very next year and by its second yea was declining.

These differences in behavior of the year classes have been the chie source of difficulty in forecasting future abundance. In the spring of 1928, when the 1923 and 1921 classes had been observed in the fishery for three years and it appeared fairly certain that a new year clas was not yet due to appear, we predicted [6] a decline in the catch, which was borne out by subsequent events; though the 1927 class augmente the population, their numbers were too few to offset the decline in th 1923 and 1921 classes.

In the spring of 1929 it was pointed out [7] the 1923 and 192 classes must continue to decline, but that it was uncertain whether the 1927 class would make a large enough contribution to offset th decline. As it turned out, the catch was much larger—due not to th 1927 class, but to the very large 1928 class that made its appearance for the first time.

Again in the spring of 1930 the prospects for the coming season were discussed.[8] At that time it appeared that the outstanding factor would be the 1928 class which, on the basis of the previous year's showing, appeared to greatly exceed the important class of 1923. But, on the contrary, this class proved to be only moderately important in 1930 while the 1923 class furnished the expected quota and the 1929 class also appeared in considerable numbers.

In 1931 [9] the prospects for the season were discussed in considerable detail. A summary of the predicted catch from each year class appears in Table 4, from which it may be seen that the forecast was 35,300,000 pounds as against a realized catch of 32,183,000 pounds;[10] a figure which is well within the estimated 5,000,000 pounds latitude allowed in the prediction.

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[6] Fishing Gazette, vol. 45, No. 4, April, 1928.
[7] Fishing Gazette, vol. 46, No. 4, April, 1929. Fishermen's Own Book and Fishing Equipment News, vol. 9, No. 3, March, 1929.
[8] Fishing Gazette, vol. 47, No. 4, April, 1930.
[9] Bureau of Fisheries, Fishery Circular No. 4, August, 1931 (approved for publication, May 25, 1931).
[10] These quantities are exclusive of yearling or "blink" and "tinker" mackerel which were excluded from the prediction. The catch included 4,300,000 pounds of blinks and tinkers, making the total 36,483,000 pounds.

BLE 4.—*Comparison of the quantities of mackerel predicted for 1931 with the quantities actually caught in 1931*

| Year class | By numbers | | Average weight | | By weight | |
|---|---|---|---|---|---|---|
| | Predicted | Caught | Predicted | Actual | Predicted | Caught |
| ne fishery: | *Number* | *Number* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 1923 and older | 8, 500, 000 | 8, 068, 000 | 2. 15 | 2. 075 | 18, 000, 000 | 16, 744, 000 |
| 1928 | 6, 000, 000 | 6, 539, 000 | 1. 50 | 1. 664 | 9, 000, 000 | 10, 882, 000 |
| 1929 | 2, 500, 000 | 1, 043, 000 | 1. 25 | 1. 336 | 3, 000, 000 | 1, 393, 000 |
| Total | 17, 000, 000 | 15, 650, 000 | | | 30, 000, 000 | 29, 019, 000 |
| t fishery: | | | | | | |
| Spring— | | | | | | |
| 1923 and older | 2, 000, 000 | 804, 000 | 2. 20 | 2. 069 | 4, 400, 000 | 1, 663, 000 |
| 1928 | | 84, 000 | | 1. 656 | | 139, 000 |
| Fall— | | | | | | |
| 1921 and older | 250, 000 | 476, 000 | 2. 25 | 2. 25 | 500, 000 | 1, 071, 000 |
| 1928 | 250, 000 | 167, 000 | 1. 50 | 1. 74 | 400, 000 | 291, 000 |
| Total | 2, 500, 000 | 1, 531, 000 | | | 5, 300, 000 | 3, 164, 000 |
| Grand total | 19, 500, 000 | 17, 181, 000 | | | 35, 300, 000 | 32, 183, 000 |

It should not be concluded from this fortunate outcome of the 31 prediction that future predictions will also be as accurate. nere are a number of things that might cause a larger discrepancy tween prediction and actual catch, such as a change in number of ssels engaged in the fishery or in the total number of days that ey fish. In the prediction for the past year it was assumed that e fishing effort would be the same in 1931 as it was in 1930. Acally, it was greater. Had it been the same, the catch would have en smaller and there would have been a greater difference between e predicted catch and the actual catch.

It is interesting to note further that the two principal items in e prediction were more accurate than the total, for the seine catch the 1923 and older classes was 16,744,000 pounds as against a preiction of 18,000,000 pounds, and the contribution of the 1928 class as 10,882,000 pounds as compared with a predicted 9,000,000 pounds. he sum of these two totals was 27,000,000 pounds in the prediction id 27,600,000 pounds in the actual catch. It is quite apparent, erefore, that the more uncertain items included the minor portions the catch, such as the relatively young fish of the 1929 class ught in the seine fishery and the various contingents of the net hery.

In reviewing the results of previous predictions two features have en in evidence consistently throughout the series: (*a*) The foreasts of abundance of year classes that have been in the fishery veral years are quite reliable; (*b*) the forecasts of abundance of the unger year classes, especially those due to appear for the first or cond time, have been much less reliable. A third feature, clearly own in the results of the 1931 prediction, is that the results of the t fishery are quite erratic, so that even the older year classes taken this form of gear may vary widely from the predicted amounts. his feature will be discussed in greater detail when taking up the ospects of this branch of the fishery in the following sections of e report. Fortunately, the percentage of the catch taken in the

net fishery is so low that departures from the prediction do not greatly affect the total season's catch.

It should also be remembered that the prediction for 1932 rests on the assumption that the mackerel fleet will continue at the same size and carry on the same amount of fishing in 1932 as it did in 1931. This assumption is forced upon us, for we know no way of foreseeing the changes in fishing effort. In the past the changes in abundance have been so profound that they have overshadowed the changes in fishing effort, and this may easily be the case in 1932. Should there be any marked changes in the intensity of fishing, the prospects as to catch would be changed accordingly.

## PROSPECTS FOR 1932

Reviewing the past experiences it is apparent that considerable latitude must be allowed for variations from the forecast in the contributions to the catch from the several year classes, especially the younger ones. In order to express the possible variations in the 1932 forecast, each year class has been studied to arrive at the "most probable" number to be expected; also the "highest probable estimate" and the "lowest probable estimate."

It has already been pointed out that seine and net fisheries differ as to their selection of sizes, hence, of year classes, and also that the net fishery is more variable than the seine fishery. It is therefore necessary to consider the two kinds of fishing separately.

### SEINE FISHERY

*Measures of abundance.*—It is well recognized that total catch statistics do not necessarily reflect the abundance of the species of fish concerned, for changes in the number of vessels engaged in fishing are likely to have a pronounced effect on the quantities of fish caught. Owing to difficulties in arriving at a more reliable measure of abundance, we have, during the past several years, relied on the total catch figures, a course that was perhaps justified, inasmuch as we knew that the fleet did not change greatly during the period under observation. To avoid possible cumulative error from this source we have, for the purpose of the present report, made computations intended to give a more reliable series of statistics based on the return per unit of fishing effort. The statistics representing the results of these computations may be designated the "index of abundance." The index of abundance may be taken to represent what the changes in catch through the series of years would have been if the same group of mackerel seiners had operated regularly throughout all of the years.[11]

While the index of abundance provides a correction for the variation from year to year in the number and efficiency of vessels engaged in the fishery, it does not make any correction for differences in the effectiveness of the fishing due to varying periods of stormy weather

[11] Actually it was not possible to find a large enough group of vessels fishing regularly throughout the 6 year period, so it was necessary to use a group of vessels operating in the first and second years, calculating therefrom the rate of change from the first year to the second; then another group of vessels operating in the second and third year to determine the rate of change between those two years; and so on, finally connecting the values by the "link relative" method. Geometric means were used in order to minimize the effects of extreme values in individual items.

changes in local availability of the mackerel. These might seriously affect the resulting values in any single year but probably would tend to balance out in the long run.

*The 1923 and older classes.*—We have seen that throughout the six years an important portion of the catch has been made up a group including 1923 and 1921 classes, together with a few er fish. (Table 5.) It has been previously demonstrated [12] that 1923 class constitutes the major portion of this group (86.5 cent), hence it is possible to consider the statistics on this group

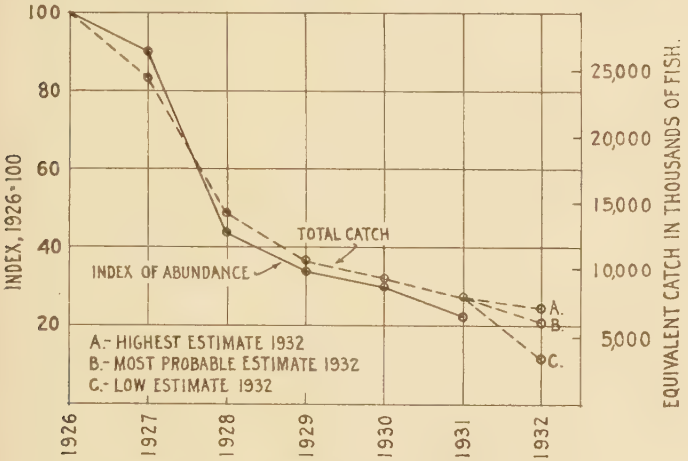


FIGURE 4.—Changes in apparent abundance of the 1923 and older classes in the seine fishery, with estimates for 1932

virtually representing the 1923 class and treat them as a single it. Knowing the number of mackerel of this group caught by the ners each year since 1926 it should be possible to judge their nual rate of decline and thus reckon their probable abundance in 32. In Table 6 and Figure 4 there is shown the catch of the 1923 d older year classes during the past six years, both according to e total seine catch and according to the index of abundance.

BLE 5.—*Numbers of seine-caught mackerel of each year class caught during the period 1926–1931, with estimates for 1932*

| Year | 1923 and older classes | 1925 class | 1926 class | 1927 class | 1928 class | 1929 class | 1930 class | 1931 class |
|---|---|---|---|---|---|---|---|---|
| [a] | 29, 180, 000 | 147, 000 | | | | | | |
| | 24, 335, 000 | (b) | 25, 000 | | | | | |
| | 14, 229, 000 | (b) | (b) | 2, 164, 000 | 127, 000 | | | |
| | 10, 667, 000 | (b) | (b) | 574, 000 | 28, 833, 000 | 225, 000 | | |
| [a] | 9, 444, 000 | (b) | (b) | (b) | 9, 602, 000 | 8, 473, 000 | 8, 000 | |
| | 8, 068, 000 | (b) | (b) | (b) | 6, 539, 000 | 1, 043, 000 | 7, 973, 000 | 213, 000 |
| igh estimate | 7, 100, 000 | (b) | (b) | (b) | 5, 800, 000 | 900, 000 | 2, 700, 000 | |
| ost probable estimate | 6, 000, 000 | (b) | (b) | (b) | 3, 900, 000 | 600, 000 | 1, 900, 000 | |
| ow estimate | 3, 400, 000 | (b) | (b) | (b) | 3, 200, 000 | 500, 000 | 900, 000 | |

[a] Data revised since the last report. [b] Negligible.

[12] Bureau of Fisheries, Fishery Circular No. 4, August, 1931.

TABLE 6.—*Relative abundance of the 1923 and older year classes, according to the total seine catch and according to the index of abundance*

| Year | Number caught by seiners | | | Index of abundance | |
|---|---|---|---|---|---|
| | Thousands of fish | Index, 1926=100 | Percentage annual decline | Index, 1926=100 | Percentage annual decline |
| 1926 | 29,180 | 100.0 | | 100.0 | |
| 1927 | 24,335 | 83.4 | 16.6 | 89.1 | 10. |
| 1928 | 14,229 | 48.8 | 41.5 | 43.9 | 50. |
| 1929 | 10,667 | 36.6 | 25.0 | 33.8 | 23. |
| 1930 | 9,444 | 32.4 | 11.5 | 29.8 | 11. |
| 1931 | 8,068 | 27.7 | 14.6 | 22.2 | 25. |

[1] Index of link relatives of geometric mean number of fish caught per regular seiner.

The most striking thing shown by the curve of abundance of the 1923 and older year classes is the sharp decline between 1927 and 1928. This decline was accompanied by a change in the seasonal character of the fishery. Prior to 1927 this group of year classes was taken by seiners virtually throughout the entire season. In 1928 they disappeared during midsummer and were not taken in significant numbers during the remainder of the season in any of the years since 1927. We are inclined to regard this as a change in availability rather than a marked decline in abundance. Since the seasonal habits of this year class have been relatively constant since 1928, this feature does not affect the curve of index of abundance for the last four years, and we may regard this portion as truly reflecting abundance.

Since we have not had opportunity, during the limited period of these investigations, to measure the abundance of a year class through its entire life history, we have no parallels to guide us in estimating the future course of the abundance curve of the 1923 class. Hence, we must resort to some method of extrapolation, at the same time recognizing that such methods are subject to grave question, especially if the mathematical nature of the curve is not known. Despite this difficulty, the range of possibilities may be designated with a reasonable degree of assurance.

Taking up first the highest probable catch that might be realized from this year class, we may use the lowest rate of decline registered by this class in any year since 1928. According to this reasoning the decrease might be as little as 11.8 per cent, which was the rate of decline between 1929 and 1930. Applying this rate we would arrive at an estimate of 7,100,000 as the highest probable number of mackerel to be expected of this year class in 1932.

While it is possible that the rate of decline used for the computation in the previous paragraph might be realized, it is much more probable that some greater rate of decline may take place. Perhaps the most probable would be a repetition of the rate observed during the past year (25.6 per cent between 1930 and 1931). Using this rate, we arrive at a prediction of 6,000,000 as the estimate of the most probable number of mackerel to be expected of this year class in 1932.

f the species has a normal limit of longevity,[13] it is possible that rate of decline may be even higher than this, for at some time ring the life of this year class it must approach this limit. When t happens there must be an acceleration in the rate of mortality. at, even now, this period is being approached is indicated per- os by the greater rate of decline between 1930 and 1931 than ring the previous year. Should the rate accelerate by the same ount during the coming year, the numbers would be reduced by 5 per cent. If this happens the catch would be only 3,400,000 h, which we may take as our lowest probable estimate.

*The 1928 class.*—The history of the 1928 class since it first appeared the commercial catch in 1929 is given in Table 7. In estimating future catch to be expected from this year class we have avail- e the experience of the 1923 class when it was at a similar age. e decrease in abundance of the latter year class was only 10.9 cent at that time. It does not appear likely that the 1928 class uld have any lower rate of decrease than this, for it has been ject to a fairly high rate of diminution during the past. Using 9 per cent, it may be computed that 5,800,000 is the highest bable number of mackerel that this year class is likely to yield 1932.

A more probable rate of decline would perhaps be a repetition the rate during the last year, which was 40.7 per cent. If this e should continue, this year class would provide 3,900,000 mack- l, which may be taken as the most probable catch during the ming year.

BLE 7.—*Relative abundance of the 1928 class during the years 1929 to 1931 according to the total seine catch and according to the index of abundance*

| Year | Catch by seiners | | | Abundance | |
|---|---|---|---|---|---|
| | Thousands of fish | Index, 1929=100 | Percentage annual decline | Index, 1929=100 | Percentage annual decline |
| | 28,833 | 100.0 | | 100.0 | |
| | 9,602 | 33.3 | 66.7 | 33.4 | 66.6 |
| | 6,539 | 22.7 | 31.9 | 19.8 | 40.7 |

We have already noted that the 1923 class experienced a fairly arp decline in yield when a change in availability caused mackerel this year class to be scarce during summer and fall. Should e 1928 class experience a similar change in availability a year rlier than did the 1923 class, distinctly fewer would be caught in 32 than indicated in the above paragraph. Whether or not the te of decline would be the same as experienced by the 1923 class, nen the change in availability occurred, we can not be sure; but

[13] This does not appear to be the case in as far as the Norwegian herring is concerned e Einar Lea; Mortality in the Tribe of Norwegian Herring. Conseil Permanent ernational pour l'Exploration de la Mer, Rapports et Procès-Verbaux des Réunions, Vol. V, pp. 100 117, 1930), but this does not preclude the possibility in the case of the ckerel.

since this is our only guide as to the quantitative effect of suc change, we must perforce use the data provided by that year clas This would indicate a 50.8 per cent reduction and provide on slightly more than 3,200,000 mackerel, which may be taken as th lowest probable estimate.

*The 1929 class.*—With reference to the 1929 class, we may arri at our highest estimate by applying the lowest rate of decline re istered by the 1923 class. This would provide a catch of somewh more than 900,000 mackerel. It is more probable, however, th this class would experience the same rate of decline as did the 19 class when it was of similar age. This was 40.7 per cent, and wou permit a catch of 600,000 mackerel. With this year class as wit the one discussed formerly there might be a change in availabili producing a greater decline. If this be the same as for the 19 class, the catch would only be 500,000 mackerel.

*The 1930 class.*—In estimating the probable catch from this ye class we may be guided by the rates of decline experienced by th year classes when they were at the corresponding age. (Table Using the lowest of these rates (66.6 per cent) in computing t highest probable catch, we arrive at 2,700,000 mackerel. Using t average rate of decline (76.2 per cent) for the most probable es mate, we arrive at 1,900,000 mackerel; and if we use the high rate of decline (89.2 per cent), the lowest probable estimate becom 900,000 mackerel.

TABLE 8.—*Rate of decline of the 1927, 1928, and 1929 classes in passing fr their first to their second year in the fishery*

| Year class | By total number caught | | | By index of abundance | | |
|---|---|---|---|---|---|---|
| | First season | Second season | Percentage annual decline | First season | Second season | Percenta annual declin |
| 1927 | 2,164,000 | 574,000 | 73.5 | 100 | 27.3 | 7 |
| 1928 | 28,833,000 | 9,602,000 | 66.7 | 100 | 33.4 | 6 |
| 1929 | 8,473,000 | 1,043,000 | 87.7 | 100 | 10.8 | 8 |
| Average rate of decline | | | 76.0 | | | 76 |

*The 1931 class.*—As mentioned before, there is very little informa tion upon which to base an estimate of the numbers of mackere likely to be provided by the 1931 class. During the coming yea this year class will have reached, for the first time, a size that i commercially desirable. During the past six years the quantities o mackerel caught from year classes of comparable age, appearing fo the first time in the commercial fishery, have been highly variable, a indicated in Table 9. While we do not find it possible to estimat the quantity likely to be caught during 1932, there is some evidenc that this year class may be more abundant than the average yea class of recent years. In the first place, the United States Bureau of Fisheries steamer *Albatross II*, in its survey of the spawning and nursery grounds of the mackerel during the spring of 1931, found these grounds to be more heavily populated with mackerel fry than in in three previous years. Secondly, young mackerel of fingerling size

re observed to be schooling in an unusual abundance at various ints along the coast from northern New Jersey to Casco Bay, Me. his would appear to indicate that abnormally large numbers of ackerel resulting from the 1931 spawning survived the hazardous rly period of growth, and if they also have survived the winter, ey should reappear as blinks and tinkers during the coming season d be taken in considerable quantities, especially if the markets rance to be in a condition to absorb large quantities of these small h at prices that would make it pay the seiners to fish for them.

BLE 9.—*Number of yearling mackerel (blinks and tinkers) caught by seiners, 1926 to 1931*

| Year | Number | Year | Number |
|---|---|---|---|
| | 147,000 | 1929 | 28,833,000 |
| | 25,000 | 1930 | 8,473,000 |
| | 2,164,000 | 1931 | 7,973,000 |

## NET FISHERY

The net fishery is confined to a few months in spring and fall. s total catch never approaches that of the seining fleet, being as a le about 8 per cent as large as the seine catch, sometimes falling low as 4 per cent, and occasionally running as high as 14 per cent. evertheless, it is important, filling the gaps during the full-moon riod in the early spring when seiners find it difficult to find the ackerel, while in late October, when the seiners usually withdraw om the fishery, the netters take it up and prolong the season rough November and sometimes into December.

It will be remembered from previous discussion that the yield of e net fishery is more variable than that of the seine fishery. This ll not greatly affect the accuracy of total prediction because the t fishery contributes such a small share of the catch that even a 0 per cent departure from predicted catch in the net fishery would use only a 10 per cent difference in the total yield for the season. Reference to Table 2 and Figure 3 makes it clear that different ar classes have dominated in the net fishery during the spring and ll. In spring the mackerel have been largely of the 1923 class, ith moderate numbers of 1928 class fish in the last few years, while the fall fishery the 1921 class has been strongly dominant, with the 28 class making considerable contribution in the last two years. ecause of these differences, it will be necessary to deal separately ith the spring and fall seasons.

*Spring fishery.*—In examining the results of the spring net fishery r the past 6 years (Tables 2, 10, and 11 and fig. 3) one is immedi- ely struck by the apparent increase from 1926 to 1930 in the num- rs of mackerel of the 1923 class, both in the total catch and in the dex of abundance. It would be absurd to regard this as an in- ease in abundance; we believe, instead, that it is due to increased ailability to this kind of gear of the mackerel as they grow older. here is a tendency for netters to catch somewhat larger mackerel an do the seiners, owing to the habits of the fish rather than to y selective action of the gear, for the nets are used in a large ariety of mesh sizes so that all except tinker and blink sizes may

be taken in so far as the gilling action of the nets is concerned. Furthermore, it is often remarked by fishermen that the larger mackerel are more scattered and swim deeper than the smaller ones. This being the case, the netters rather than the seiners are likely to catch them, for in the former method of fishing it is not necessary that the fish be compactly schooled and showing at the surface. Hence, we may assume that the mackerel of the dominant 1923 class became increasingly available to the netters as they grew older. Obviously this process could not continue indefinitely, for at some point during the history of the year class the rate of mortality must outstrip the increase in availability, so that the curve of catch per netter must inevitably decline. This, in fact, happened in 1931.

TABLE 10.—*Numbers of net-caught mackerel of each year class caught in spring, 1926–1931, with estimates for 1932*

| Year | 1923 and older year classes | 1927 year class | 1928 year class |
|---|---|---|---|
| 1926 | [1] 1,063,000 | ---- | ---- |
| 1927 | 685,000 | ---- | ---- |
| 1928 | 1,197,000 | ---- | ---- |
| 1929 | 1,747,000 | 6,000 | ---- |
| 1930 | 2,059,000 | (2) | 53,000 |
| 1931 | 804,000 | (2) | 84,000 |
| 1932: | | | |
| High estimate | 1,100,000 | ---- | 300,000 |
| Most probable estimate | 800,000 | ---- | 200,000 |
| Low estimate | 400,000 | ---- | 100,000 |

[1] Revised since last report. [2] Negligible.

TABLE 11.—*Relative abundance of the 1923 and older year classes according to the total spring net catch and according to the index of abundance*

| Year | Number caught by spring netters | | Index of abundance (1926=100) | | |
|---|---|---|---|---|---|
| | Thousands of fish | Index 1926=100 | Actual [1] | Theoretical [2] | |
| | | | | First assumption | Second assumption |
| 1926 | 1,063 | 100 | 100 | ---- | ---- |
| 1927 | 685 | 64.4 | 109.6 | ---- | ---- |
| 1928 | 1,197 | 112.5 | 142.1 | ---- | ---- |
| 1929 | 1,747 | 164.2 | 146.8 | 146.8 | 146.8 |
| 1930 | 2,059 | 193.5 | 158.2 | 129.5 | 146.8 |
| 1931 | 804 | 75.6 | 82.5 | 96.3 | 113.6 |

[1] Index of link relatives of geometric mean number of fish caught per regular spring netter.
[2] See text for explanation.

But before considering the decline in 1931 another peculiarity of the spring netter fishery must be pointed out; that is, the dependence on bright moonlight nights for the best fishing. Fishermen state that on dark nights the luminescence formed by the disturbance of the net in the water scares the fish away from it, while on bright nights this difficulty does not exist. Certainly, conditions must be

most favorable on moonlight nights, for the largest catches are made during the full-moon period, as is plainly shown by statistics on daily landings too voluminous to reproduce in this report. This has a marked effect on the catch, for the spring netting season extends only through about one and a half lunar cycles, and the success of the fishery depends partly on whether full moon occurs in mid season or toward either end.

With this preparation we may consider the results of the 1930 and 1931 spring netting seasons. In 1930, full moon was on May 12, very close to mid season. As a result, the catch was unusually large. In 1931, on the other hand, the phases of the moon were most unfavorable to this fishery, for the bright nights were toward the beginning and the end of the season (May 2 and 31) while dark nights prevailed during mid season, when the catches are usually largest. As a consequence, the quantities of mackerel caught in this branch of the fishery were distinctly lower than might otherwise have been the case.

Unfortunately, we are at present without means of arriving at the quantitative effects of the coincidence of lunar phases with the netting season, hence can not correct the curve of catch or index of abundance. More general reasoning must, therefore, be resorted to, when considering the probable catch of this fishery during 1932. Since it involves some untested assumptions, the forecast on this item will be admittedly less reliable than that on some of the other items.

Taking first the 1923 class, it will be assumed that by 1929 the tendency toward increased availability had approached its maximum and that thereafter the death rate has been the major influence in the results of the fishery (except for the lunar phases). This being the case, we should have expected the catch of the 1923 class in the spring netting season to decline at approximately the same rate as in the seine fishery. This would have been 11.8 per cent in 1930 and 25.6 per cent in 1931, and the theoretical curve of index of abundance in Figure 5 would have followed the course indicated by the dotted line, instead of the empirical curve which we consider unreliable due to effects of the moon phases which caused a larger than normal catch in 1930 and lower than normal catch in 1931.

Assuming the dotted line to express the decline in abundance more truly than does the solid line, the estimated probable catch for 1932 would become 800,000 if the decline were to continue at the same rate. This may be regarded as the most probable estimate.

Circumstances that might lead us to expect a larger catch involve assuming that the availability continued to increase between 1929 and 1930 to the extent of compensating for mortality, thus raising the abundance in 1930 and 1931 to a place 17 index units higher than in the dotted line of Figure 5; and, furthermore, if we assume a moderate decline of 11.8 per cent (such as occurred in this year class in the seine fishery between 1929 and 1930) in 1932 the catch would be 1,100,000. This would constitute the highest probable estimate.

If the index curve as shown by the solid line in Figure 5 be accepted as showing the true decline in abundance between 1930 and 1931, and it also be assumed that the same rate (52.1 per cent) is to

continue between 1931 and 1932, then the catch would be 400,000 mackerel in 1932. This may be regarded as the lowest probable estimate.

In addition to the 1923 class there have been only a few mackerel of the 1928 class taken in the spring net fishery. As these grow older we should expect them to become increasingly available to the net fishery. In passing from the 1930 to the 1931 season the catch per netter of this year class increased more than 100 per cent, in spite

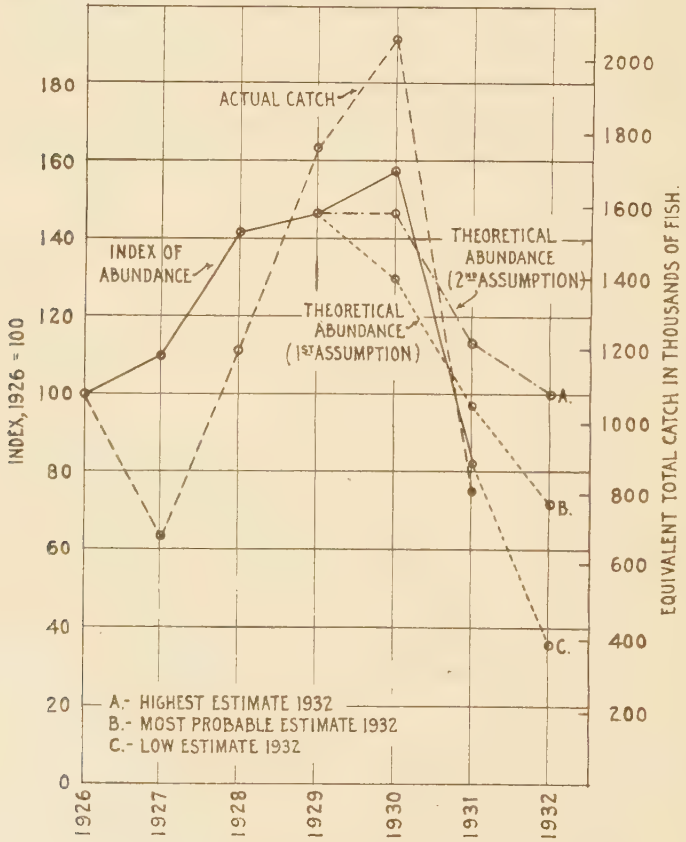


FIGURE 5.—Changes in apparent abundance of the 1923 and older year classes in the spring net catch with estimates for 1932

of the unfavorable conditions for spring netting. It is conceivable that with increased availability and more favorable fishing conditions the catch from this year class might be in the neighborhood of 300,000 mackerel, a figure which may be taken as the highest probable estimate. It is more likely that they may increase at a smaller rate, so as to provide a catch of about 200,000 fish. This we regard as the most probable estimate. Should there be insufficient increase in availability to offset the decline due to mortality, the catch would be the same as in the previous years—about 100,000 mackerel. This is the lowest probable estimate.

*Fall fishery.*—Fall netting takes place after the seining season is over. It extends through a relatively short period of time (late October to early December) and in a restricted area (the northern portion of Massachusetts Bay and the offing of Cape Ann). The lateness of the season is conducive to more interruptions by stormy weather than in summer, and the shortness of the season causes such interruptions to have greater relative effects on the catch in one year as compared to another. So it is not surprising that there should be the marked changes in the annual catch in this fishery as shown in Table 12. Furthermore, in predicting the probable catch during the coming year, there is more uncertainty than in the items considered heretofore. To remove some of the uncertainties as to relative abundance in the past, an index of abundance has been computed, based on the average catch per trip per regular netter. In this way the effects of stormy weather and duration of the season are to a considerable extent avoided.

TABLE 12.—*Numbers of net-caught mackerel of each year class caught in fall, 1926–1931, with estimates for 1932*

| Year | 1921 and older year classes | 1927 year class | 1928 year class |
|---|---|---|---|
| 1926 | 122,000 | | |
| 1927 | 291,000 | | |
| 1928 | 906,000 | | |
| 1929 | 260,000 | 12,000 | |
| 1930 | 325,000 | [1] | 176,000 |
| 1931 | 476,000 | [1] | 167,000 |
| 1932: | | | |
| High estimate | 400,000 | | 400,000 |
| Most probable estimate | 200,000 | | 200,000 |
| Low estimate | 100,000 | | 100,000 |

[1] Negligible.

TABLE 13.—*Relative abundance of the 1921 and older year classes, according to the total fall net catch and according to the index of abundance based on the average catch per trip*

| Year | Number caught by fall netters | | Index of abundance [1] (1926=100) | |
|---|---|---|---|---|
| | Thousands of fish | Index 1926=100 | Actual | Theoretical [2] |
| 1926 | 122 | 100 | 100 | 100 |
| 1927 | 291 | 238.5 | 59.7 | 75 |
| 1928 | 906 | 742.5 | 89.4 | 56 |
| 1929 | 260 | 213.1 | 32.0 | 42 |
| 1930 | 325 | 266.4 | 24.8 | 32 |
| 1931 | 476 | 390.2 | 35.6 | 22 |

[1] Index of link relatives of geometric mean number of fish caught per regular fall netter.
[2] See text for explanation.

The abundance as measured by this method (fig. 6) is decidedly less erratic than indicated by total catch (Table 12), but there is sufficient irregularity to cause difficulty in arriving at a sound reckoning of the rate of change in abundance. To do this a logarithmic

curve has been drawn that appears to fit the observed points approximately. If this theoretical curve be regarded as expressing the changes in abundance, the catch of the 1921 and older year classes was about 60 per cent larger in 1931 than the trend of abundance would have led us to expect. In other words, had it not been for abnormal conditions of some sort, the catch would have been about 300,000 instead of 476,000 mackerel in that year. Should the abundance curve continue its present course through another year, there would be a 22 per cent decline and only 200,000 fish of this group of year classes would be caught in the fall net fishery in 1932. This figure constitutes our estimate of the most probable catch.

The uncertainties as to success of this fishery being as they are, it does not appear unreasonable that the catch might turn out to be twice or half the most probable estimate. This would make 400,000 and 100,000 mackerel the highest probable estimate and lowest probable estimate, respectively.

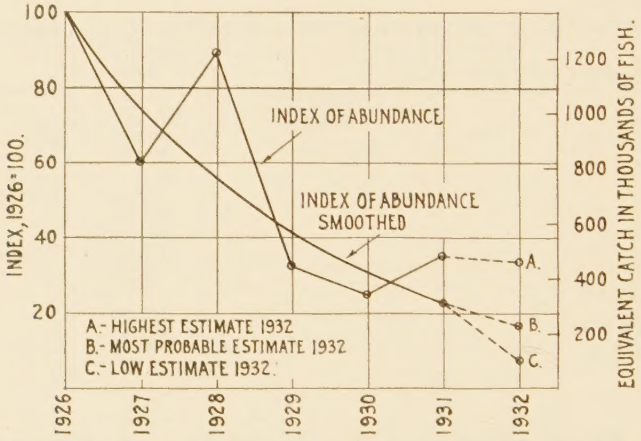


FIGURE 6.—Changes in apparent abundance of the 1921 and older classes in the fall net fishery according to an index of abundance based on the average catch per trip, with estimates for 1932

The 1928 class contributed 176,000 and 167,000 fish to the fall netters' catch in 1930 and 1931, respectively. According to the catch per trip per regular netter the decline between 1930 and 1931 was about 6 per cent. Should this rate persist another year, the catch would amount to somewhat less than 200,000 fish, which may be considered the most probable estimate. Again allowing fortuitous circumstances to double or halve this figure, we have 400,000 fish as the highest and 100,000 fish as the lowest probable estimates.

## SUMMARY

We have estimated the number of mackerel that most probably will be provided by each year class in the catch of the seine and net fisheries in 1932; it only remains to translate these to poundage and add them, as has been done in Table 14. The result is 26,000,000 pounds. While this is the most probable catch, we have seen that in arriving at the estimate of each item, questions of interpretation

of the past records and errors of observation have been such as to suggest, in each case, the possibility of higher or lower catches. These departures from the most probable estimates have been expressed as the highest probable estimates and lowest probable estimates. While it is likely that any one of the items may turn out to have the highest or lowest values, the chances that all would have the highest or the lowest value are almost nil, so that the sum of the values are almost without significance in expressing the accuracy of the prediction. General consideration of chance variations leads to the belief that the catch may very likely differ by about 5,000,000 pounds but is most unlikely to differ by as much as 10,000,000 pounds from the predicted total of 26,000,000.

TABLE 14.—*Summary of estimates of most probable catch (exclusive of blinks and tinkers) in 1932*

| Year class | Number | Average weight | Pounds |
|---|---|---|---|
| Seine fishery: | | | |
| 1923 and older | 6,000,000 | 2.10 | 12,600,000 |
| 1928 | 3,900,000 | 1.80 | 7,000,000 |
| 1929 | 600,000 | 1.57 | 900,000 |
| 1930 | 1,900,000 | 1.40 | 2,700,000 |
| Total | 12,400,000 | | 23,200,000 |
| Net fishery: | | | |
| Spring— | | | |
| 1923 and older | 800,000 | 2.12 | 1,700,000 |
| 1928 | 200,000 | 1.84 | 400,000 |
| Fall— | | | |
| 1921 and older | 200,000 | 2.25 | 500,000 |
| 1928 | 200,000 | 1.87 | 400,000 |
| Total | 1,400,000 | | 3,000,000 |
| Grand total | 13,800,000 | | 26,200,000 |

The prediction and the allowance for error rest on the assumption that approximately the same fleet will operate during 1932 as were in the fishery in 1931. No allowance has been made for possible changes in the number of vessels fishing; the length of time they may stay in the fishery; the interruptions that might be caused by natural conditions, such as bad weather; and economic conditions, such as prices below the cost of production. These things may have an appreciable effect on the catch, but are unpredictable, at least from the biological standpoint. Persons in close touch with the fishery must form their own estimates as to the degree to which such influences may alter the productivity of the fishery.

Furthermore, it must be remembered that the prediction does not include the yearling or tinker mackerel which might or might not show up in considerable numbers during the coming season. While there are a few indications that there may be an unusually good run of tinkers, the facts are not sufficiently clear to warrant any prediction. A solution to the problem of anticipating future yields of tinkers is being sought by means of annual surveys of the mackerel spawning and nursery grounds, but the project has not yet continued through enough seasons to provide any basis for such estimates.

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